Tomorrow=s Brainchild: The first years last forever

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Holding the baby in your arms, you speak in that singsongy voice adults use with infants. The little girl coos in response. When you tickle her stomach with a gentle finder, she laughs and flails her arms. Over and over, you waggle your head and zoom your nose down to tenderly touch hers, all the while repeating, AI see you, I see you.@ It=s the kind of soft and seemingly unimportant moment that occurs millions of time each day around the world.

Tender for the adult, perhaps, but not for the baby-or at least the baby=s brain. Fireworks are going off inside that infant organ. Neurons by the thousands shoot out connections. Chemical relays zip messages to-and- fro like Morse code gone mad. Synapses fire, reload, and fire again faster than anyone ever could count.

And trivial? Hardly. A human brain is being wired. Layer by rapid-fire layer, a mind is being molded. With each simple movement, sound, or touch, the pathways of this child=s intellect are being built. The kind of person this baby will become is being etched - literally - into the grayish mush inside that tiny skull. Multiple components of this infant=s mental makeup-from IQ to personality to emotions - are under construction.

AThese interactions - eye to eye contact, singing , rocking, - actually cause physiological changes," says Bruce Perry, MD, a professor of child psychiatry at the Baylor College of Medicine in Houston, Texas. AThey grow the brain. This isn=t warm, lovely, liberal stuff. This is biology. This is the way the brain works."

Barely a decade ago, almost everyone believed that the quality and structure of a baby=s brain was forged at conception. Genetic heritage, it was thought, determined mental attributes just as it does eye color and blood type. Today, researchers know that genetics is only a part of brain development; that much of this organ=s eventual architecture and potential is determined not by chromosomes but by the environment in which the baby lives.

AVery early in childhood, the automatic responses subside, and the rest is left up to the parents or caretakers,@ says Harry Chugani, MD, a pediatric neurologist at the Wayne State University School of Medicine in Detroit, Michigan. AThat is when the fun begins.@ Sociologists, educators, parents and others now are scrambling to understand the ramifications of this amazing revelation.

Though much remains to be learned, researchers quite likely have discovered more about the brain in the past decade than in all history combined. Ancients considered the brain an unopenable black box, and Aristotle called it Aan organ of minor importance@ (unlike the heart, which he thought was the seat of humanness). Today, the mysteries of the human brain are being peeled away like onion layers to reveal what is perhaps the most incredibly intricate process in the universe.

The breakthrough in understanding infant brain development began in the 1970's with experiments performed by Harvard University researchers Torsten Wiesel and David Hubel in Cambridge, Massachusetts. These scientists sewed shut one of the eyes of several newborn kittens, leaving the other eye untouched. Two weeks, later they removed the stitches, and to their amazement the felines remained forever blind in the affected eyes while seeing normally with the eye that had not been covered. From this, Wiesel and Hubel concluded that the brain develops the ability to interpret images only if it is stimulated to do so during a relatively brief window soon after birth. Without visual stimulation, the portion of the brain that normally would deal with those images atrophies or becomes devoted to other tasks.

As an immediate effect of this revelation, physicians began removing cataracts from new-born babies soon after birth, rather than waiting for the infants to gain strength as had been the accepted practice (which often ended with sight loss anyway).

But the impact of this discovery reverberated far beyond the halls of ophthalmology. Is it possible, asked scientists everywhere, that other human brain functions also depend upon timely stimulation? The answer turned out to be a resounding Ayes.@ The developing human brain, Chugani says, Ais particularly open to certain stimulations at certain times. Once that time is up, you never can recapture that unique ability.

In one study at the University of Illinois at Champagne-Urbana, neuroscientist Bill Greenough divided laboratory rats into two groups He provided one group with all manner of stimulation: exercise devices, toys, playmates, and a colorful environment. The other rats lived unstimulated lives in standard lab cages. Later, Greenough studied the animals= brains under a microscope and found that the stimulated rats had developed 25 percent more neural connections than their bored counterparts. Unquestionably, their environment had made them smarter.

Other research has demonstrated that human brains benefit from early stimulation as well. In one study in Alabama, researcher provided considerable enrichment (including good nutrition, abundant playmates, and interesting toys) for three years to a group of impoverished children. Other kids from similar families and neighborhoods were monitored but received no stimulation beyond what families provided. In the end, the youngsters with the enriched lives averaged twenty points higher on IQ tests.

Additional research has found that children exposed to inadequate amounts of play and touching develop brains that are 20 to 30 percent smaller than normal. Astonishing as it may sound, a baby=s brain is, to a significant extent, constructed with the building blocks of experiences.

The more researchers learn about child brain development, the more complex they find it to be. By the time an infant takes that first breath of air he or she already has all the brain cells life will require: about 100 billion. But this fledgling brain is, well, a jumbled mess, a work of great potential but of little current ability.

Because this organ runs, in part, on electrical signals, people often speak of the brain=s Awiring.@ In these terms, a newborn has a few basic systems prewired in the womb, evidenced by the fact that at birth, he or she can breathe, pump blood, make sounds digest food, and so on. And, of course, an infant=s sensory organs all work, though mostly in a primitive, minimal way. It is, says one researcher, as if while in the womb the brain made its best guess as to what might be required in the air-breathing world.

Most of a baby=s neural wiring, however, remains to be hooked up. Billions of cells stand ready to send and receive information, but few of these neurons are properly connected. One by one, the newborn=s brain proceeds to organize these wires based on sensory input. As the baby experiences sights, sounds, touch and other stimuli, neural cells scramble to handle this stream of data , sometimes actually migrating to the regions of the brain where they are needed.

The developing brain, figuratively throbbing with activity like a nuclear reactor, connects each neuron to as many as 15,000 others (sometimes at the rate of billions of connections per second) to form a chemical-electrical labyrinth of incredible complexity.

AAt the age of eight months, a baby may have an astounding 1,000 trillion synapses in his brain,@ says Matthew Melmed, executive director of the United States child advocacy group Zero to Three. This paroxysm of growth actually creates billions more synapses than the brain eventually will use - apparently nature=s way of being ready for every contingency. In part, this why an aboriginal hunter, who hears every rustle, and a metropolitan cab driver, who tunes out a cacophony of noise, can get by with similar human brains.

As repetition confirms that a particular experience - being held by a parent, for example -indeed will be a continuing part of life, more and more neurons form links in support of this activity. But the brain, says Ronald Kotulak, author of *Inside the Brain*, Ais the ultimate use-it-or-lose-it machine. It gets better and better through exercise but >rusts= with disuse.@

Even after synapses are established, they must be used repeatedly, or the brain decides they are deadweight and either finds another purpose for them or eliminates them entirely, It is not unlike a huge tree pruning itself of branches unlikely to ever produce fruit. At peak activity, the brain may eliminate unused synapses at the rate of thousands per second. While neural connections that get used and reused are soldered in place, this winnowing process continues until about the age of puberty when the wiring of the brain is complete.

Brain growth, however, does not occur at a steady pace but rather in spurts. AAnd timing is crucial,@ says the report Rethinking the Brain from the Families and Work Institute in New York.

AThere are prime times for optimal development, periods during which the brain is particularly efficient at specific types of learning.@

Indeed, from birth through age ten or so, windows of learning opportunity open, then eventually close - just as it did for the Harvard University research kittens. Most human brain connections for vision, for example, are in place by the age of eight months. And speech usually is impossible before the age of about eighteen months, when a baby=s brain suddenly seems to say, AOK, for the next couple of years we=re going to learn to talk.@

The learning of language is one of the most important activities of the developing infant brain - and one that is totally dependent upon sensory input. Even before a baby leaves the womb, it can recognize its native language and mother=s voice. AIt seems that our mother tongue is truly our mother=s tongue,@ says Anthony DeCasper, a psychologist at the University of North Carolina at Greensboro. And immediately after birth, the developing brain begins soaking up sounds and words as a dry sponge soaks up water droplets.

Normal babies are born with the same general capability for learning language - that is, the ability to distinguish between sounds and eventually to vocally reproduce them. The brain, however, establishes neural connections for only those sounds the infant hears repeatedly. By about age ten, these language connections are mostly complete, and from that point on the person will have difficulty distinguishing and reproducing additional new sounds.

For example, the sounds Ar@ and Al@ (as in the syllables Ara@ and Ala@) are distinctly different in English but virtually identical in Japanese. Consequently, babies in English-speaking families learn to distinguish between the two, but babies in homes where Japanese is spoken do not. Once the language learning window closes, Japanese speakers have great difficulty hearing and reproducing distinct Ara@ and Ala@ sounds. Similarly, babies in English-speaking homes never learn the initial Ang@ sound found in some Asian tongues, and French youngsters fail to distinguish between the Ath@ sound in the words Athick@ and Athen.@

None of this, of course, has anything to do with genetics or ethnicity but rather with the sounds the infant hears. ALanguage is not a cultural artifact that we learn the way we learn to tell time or how the federal government works,@ says Steven Pinker in his book *The Language Instinct*. AIt is a distinct piece of (our) biological makeup.

And humans are not necessarily restricted to only one tongue. Because of the rapid-fire formation of synapses during this window of language opportunity, most young children can learn a second language right along with the first. Simultaneously exposed to a pair of languages, the phenomenal young brain will separate the two and even allow the child to speak each without a telltale accent.

But just as the language window opens in a young brain, so does it close. A child who is not exposed to speech by about age ten never will learn to speak properly. In addition, a second language can be difficult to learn-and almost always accompanied by the accent of a nonnative speaker - after this window closes. (Of course, some neural windows remain at least partially open one=s entire life. Adults do learn new languages, and anyone of any age can add new words to his or her vocabulary.)

Brain development research has unearthed another surprising discovery: Children exposed to music at a young age often develop the skills necessary to master such seemingly unrelated disciplines as complex mathematics, engineering, and chess. The mechanics of all this remain somewhat fuzzy, but it appears that music - especially classical music, with its pronounced rhythms and patterns -stimulates the same areas of the brain that later will be responsible for learning the temporal/spatial reasoning required for the other skills.

But it is not just an affinity for language or mathematics that is sculpted in those first few years. Many child development experts now believe that the basic wiring for everything from emotions to memory to high blood pressure is laid down during this time.

AWhat happens to children=s brains when the (sensory) buttons are pushed, or not pushed, can determine their IQ and whether they will become mentally retarded, sick, aggressive, violent, and even if they will live or die,@ says author Ronald Kotulak.

Researchers have found that the sense of touch may provide some of the most crucial input of all. In the 13th century, Roman Emperor Frederick II set up an experiment in which several infants were taken from their families and put in the care of nurses who were instructed to feed and bathe the babies but not hold, hug, or talk to them. He wanted to find out what language the children would speak if they grew up hearing none. That answer never was revealed, because the babies all died. Experts today suspect that lack of touching may have been the reason.

More recently, Saul Schanberg, a biological psychologist at Duke University in Durham, North Carolina, found that rat pups failed to grow and thrive when deprived of their mother=s touch - in the form of licking. Interestingly, surrogate stroking by humans with wet paintbrushes seemed to provide the required tactile stimulation the baby rats needed. Human parents, of course, don=t lick their babies, but they do hold, nuzzle, stroke and rub them, and these actions appear to promote brain-controlled functions like weight gain, motor skills, and restful sleep while reducing stress, hyperactivity, and other undesirable effects.

An infant left alone for endless hours in a crib may be two years old before it can sit up unaided or three years old before it can walk, presumably because the absence of stimulation prevents important synapses from forming.

An appalling example of this kind of neglect was discovered in Romania after the fall of Communist leaders in 1989. International humanitarians found orphanages crowded with thousands of children who had been given adequate custodial and medical care but who never had received any affection. Though healthy in some respects, these Romanian youngsters suffered from myriad developmental disorders.

One of the most crucial shortages in these children=s lives appeared to be loving, touching attachments to other humans. AChildren learn in the context of important relationships, Zero to Three=s Matthew Melmed says. AIf that emotional component is missing, brain connections won=t be made.

But problems also can occur when a baby receives abundant stimulation - of the wrong kind. Maybe parents and other family members often yell at one another. Or the baby is handled roughly. Or there is a revolving door of adult care-givers. Or the child is abused. These types of stimulation can create the wrong kinds of synaptic connections, making the developing brain forever susceptible to inappropriate responses.

A baby that repeatedly is exposed to stress and fear, for example, may grow into an adult who flies off the handle at the slightest provocation or becomes fearful of ever trying anything new. AEarly exposure to violence, stress, and other environ-mental pressures can cause the brain to run on a fast track, increasing the risk of impulsive actions and high blood pressure,@ Kotulak says.

For ages, everyone from parents to criminologists has debated whether it is nature (genetics) or nurture (environment and upbringing) that molds each person into a finished product. Today, it is clear that this enigma never can be answered-because it is the wrong question. Rather than being an either/or proposition, genetics and environment work together to create each unique individual. In the words of one researcher: AIt is not a competition. It=s a dance.@

Sadly, however, this is a minuet that rarely makes the headlines. While impotence cures and weight-reduction techniques flood the media, colossal breakthroughs in the understanding of child brain development pass almost unnoticed. AUnless this research finds its way into our homes, health clinics, early-childhood centers and classroom, (we) will remain locked in a 19th century paradigm, A says the Families and Work Institute. And million of children will be less than they could be, because the first years last forever.

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